US009410020B2

(12) **United States Patent**
Matyjaszewski et al.

(10) **Patent No.: US 9,410,020 B2**
(45) **Date of Patent: Aug. 9, 2016**

(54) **PROCESSABLE SELF-ORGANIZING NANOPARTICLE**

(71) Applicant: **CARNEGIE MELLON UNIVERSITY**, Pittsburgh, PA (US)

(72) Inventors: **Krzysztof Matyjaszewski**, Pittsburgh, PA (US); **Michael Bockstaller**, Pittsburgh, PA (US)

(73) Assignee: **CARNEGIE MELLON UNIVERSITY**, Pittsburgh, PA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/373,553**

(22) PCT Filed: **Jan. 28, 2013**

(86) PCT No.: **PCT/US2013/023421**

§ 371 (c)(1),
(2) Date: **Jul. 21, 2014**

(87) PCT Pub. No.: **WO2013/158183**

PCT Pub. Date: **Oct. 24, 2013**

(65) **Prior Publication Data**

US 2015/0005452 A1 Jan. 1, 2015

Related U.S. Application Data

(60) Provisional application No. 61/632,643, filed on Jan. 27, 2012.

(51) **Int. Cl.**
C08L 33/12 (2006.01)
C08J 3/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***C08J 3/02*** (2013.01); ***B81C 1/00031*** (2013.01); ***C08J 3/005*** (2013.01); ***C08L 25/06*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... B82Y 30/00; C08L 101/005; C08G 83/003
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,763,548 A 6/1998 Matyjaszewski
5,789,487 A 8/1998 Matyjaszewski
(Continued)

FOREIGN PATENT DOCUMENTS

WO WO0228912 A2 4/2002
WO WO2008062975 A1 5/2008
WO WO2013158183 A2 10/2013

OTHER PUBLICATIONS

Voudouris, Panayiotis et al., Anisotropic Elasticity of Quasi-One-Component Polymer Nanocomposites, Acsnano, 2011, vol. 5, No. 7, 5746-5754.
(Continued)

Primary Examiner — Michael A Salvitti
(74) *Attorney, Agent, or Firm* — Bartony & Associates. LLC.

(57) **ABSTRACT**

A method of forming a composition includes adding together a plurality of particle brush systems wherein each of the particle brush systems includes a particle and a polymer brush including a plurality of polymer chains attached to the particle. The plurality of polymer chains of the polymer brush exhibit two chain conformations as the degree of polymerization of the polymer chains increases so that the polymer brush includes a concentrated polymer brush region with stretched polymer chains and a semi-dilute polymer brush region with relaxed chains that is radially outside of the concentrated polymer brush region. The degree of polymerization of the polymer brush is no less than 10% less than a critical degree of polymerization and no more than 20% greater than the critical degree of polymerization. The critical degree of polymerization is defined as the degree of polymerization required to achieve a transition from the concentrated polymer brush region to the semi-dilute polymer brush region.

24 Claims, 14 Drawing Sheets